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OYSTER FARMING

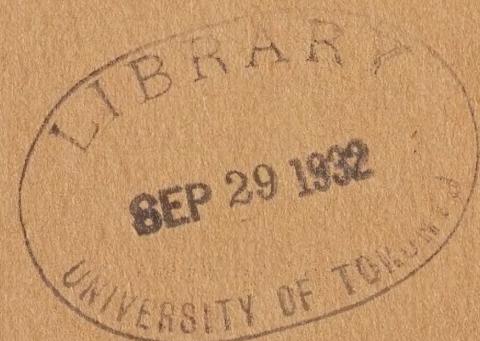
ON THE

ATLANTIC COAST OF CANADA

A Bulletin of Information and Instructions for
the Use of Oyster Farmers

BY
A. W. H. NEEDLER
ZOOLOGIST IN CHARGE OF ATLANTIC OYSTER INVESTIGATIONS,
BIOLOGICAL BOARD OF CANADA

PUBLISHED BY THE DEPARTMENT OF FISHERIES,
HONOURABLE E. N. RHODES, M.P.,
ACTING MINISTER



OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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OYSTER FARMING ON THE ATLANTIC COAST OF CANADA

Oysters have been fished to be eaten or sold from the days when our coast was first settled. But oyster *farming* is a comparatively new industry for the Atlantic coast of Canada.

The same species of oyster has been farmed profitably for many years on parts of the Atlantic coast of the United States. But the conditions in the oyster areas of the Maritime Provinces differ from those farther south. We are at the extreme northern limit of the oyster's range, where the water becomes in summer just barely warm enough for the oysters to reproduce successfully. Because our conditions are different in this and in other ways, we cannot use methods which have been successful elsewhere and be sure of their success here. We must test all methods locally and develop our own variations and improvements to suit our conditions.

At this early stage a complete guide for the oyster farmer could not be written. The information given here leaves many gaps to be filled in as our experience widens and as the results of more studies and experiments come to light. A brief summary of the oyster's manner of life is given first, because everything we do in oyster farming must be based upon our knowledge of it. A few remarks follow on the necessity for oyster cultivation and its place in the industry. Then methods are discussed briefly, using as far as possible the results of investigations in our own area.

It is hoped that this information may be helpful. There is reason to believe that profitable oyster farming can be developed in our waters. But it has not yet passed the experimental stage. Every farmer must regard himself as a pioneer. He will have the pioneer's struggle to prepare his ground for profitable cultivation. He will need, like the pioneer, to protect his crops from marauders, human or otherwise. Like the pioneer he will need every effort of body and mind to make a success, and he will have to be on the watch to improve his methods to suit his particular conditions.

A—THE LIFE STORY OF AN OYSTER

SPAWNING AND FERTILIZATION: In the early part of each summer the mature oysters in our waters develop a milky layer covering most of the surface of the body. In the females this layer contains tremendous numbers of very small eggs (according to the latest estimates up to 500,000,000 in a large female), and in the males even greater numbers of sperms. If the water becomes warm enough (about 68 degrees Fahrenheit, or preferably warmer) and if other conditions are favourable, the oysters spawn, and the eggs and sperms are shed into the water. When shed, the eggs are about 1/500th of an inch in diameter and the sperms have a head about 1/10,000th of an inch in diameter and a threadlike tail about 1/500th of an inch long by means of which they can move about in the water.

The eggs are fertilized by uniting with sperms in the water after spawning and, especially where oysters are scarce, some of the eggs may never develop because they fail to meet sperms.

THE FREE-SWIMMING PERIOD: In a few hours a fertilized egg develops into a small "larva" which swims about by means of vibrating hairs on its surface. A shell soon appears and grows until it covers the larva which then looks somewhat like a small clam about 1/300th of an inch long. The shelled larva can swim by means of a disc bearing vibrating hairs which is thrust out in front between the two halves of the shell. The larva is so small that even by vigorous swimming it cannot move fast; but the swimming can keep it up in the water or the disc can be pulled inside the shell, letting the larva sink to the bottom.

The larva feeds on very small animals or plants, or pieces of them, in the water. It grows rapidly, doubling its size twice in from two to three weeks. It is then ready to settle and is about 1/75th of an inch long—barely visible to the naked eye. The shell has changed its shape and one of its halves or "valves" has become more curved than the other.

In our waters the free-swimming period usually lasts about three weeks, being less when the water is warmer. During this time a large proportion of the small oysters die, only a small percentage of the fertilized eggs reaching the stage when they are ready to settle.

SETTLING OR "SETTING": When ready to settle the larva seeks a suitable surface to which it cements itself by the more curved half of its shell. The young oysters will settle on many different kinds of surface (shells, stones, brush, leather, iron, glass, etc.) but the surface must be firm and clean, with little or no silt or slime (a growth of minute plants). In most places where oysters grow there is much mud and a strong growth of slime, so that the young oysters have difficulty in finding a surface to which they can attach themselves and a large proportion may be lost. Probably the oyster farmer's chief way of increasing the production is to provide clean material at the proper time so that a greater number of young oysters can settle and survive.

NEWLY SETTLED OYSTERS OR "SPAT": After settling the oyster cannot again move. For the rest of its life it obtains its food from the water which is made to flow through its shell by minute hairs beating rhythmically. It has an elaborate mechanism by which the solid particles are taken from the water; some are selected and taken into the mouth and the rest are rejected.

Under favourable conditions the newly settled larvæ or "spat" grow quickly and in our waters may be well over an inch long before winter; but some are still less than a quarter of an inch long. Often 25 larvæ or more will settle on one square inch of good surface and of these perhaps only one will survive, crowding or starving out the others. Many are also killed by smothering under mud, seaweed, mussels, etc. A single starfish—the worst enemy in our waters—may kill many spat in a day. So that there is a high death-rate among the spat.

Larvæ attach themselves in our waters from half-tide level to a depth of forty feet or more, the greatest numbers being just below low tide in the Malpeque Bay area. Under natural conditions the "set" is often most abundant about low-tide level where the waves keep the stones or shells cleaner than elsewhere. But in this situation many are crushed by the ice or frozen into it and carried away. Cultivation can overcome this natural loss to some extent by collecting spat in this zone and removing it before winter to deeper water out of reach of the ice.

GROWTH: Atlantic coast oysters stop feeding when the water gets colder than about 41 degrees. With us the water is usually colder than this for six months (November to April) so that all the growth is in the six warmer months. Our oysters usually take from three to five growing seasons after their first winter to reach marketable size, i.e., oysters settling as spat in the summer of 1950 would be of marketable size in the autumn of 1953, 1954 or 1955. ("Marketable size" means here a length of three and a half inches for oysters of "round" shape and of four inches for others.) As both the shape and the rate of growth

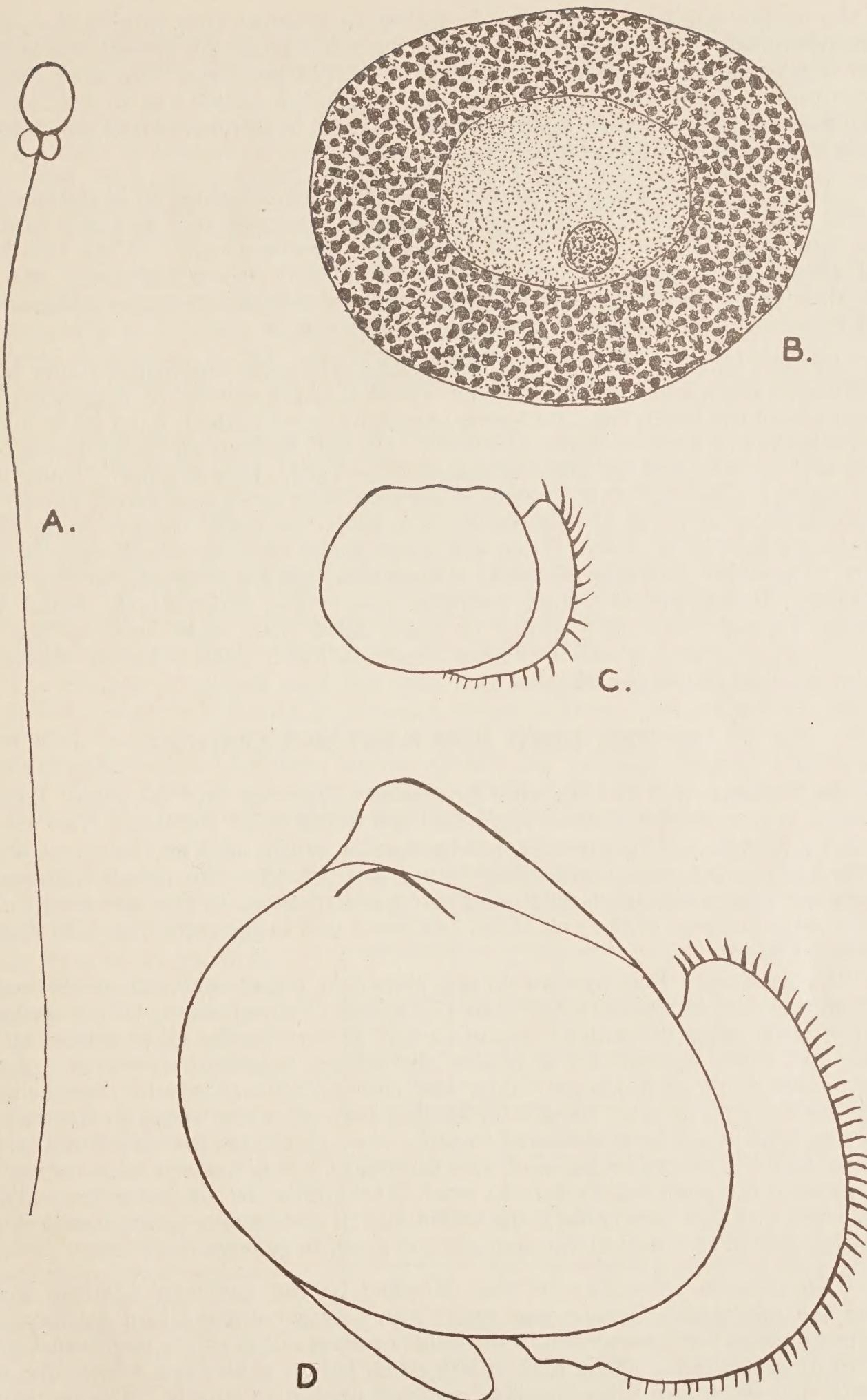


FIGURE 1. (A.)—An oyster sperm. The head is about $1/10,000$ of an inch in diameter, and the tail is about $1/500$ of an inch long. (B.)—An oyster egg. It is about $1/500$ of an inch in diameter. (C.)—A young oyster larva about $1/300$ of an inch long. Note the "velum" or disc bearing the hairs by the vibration of which the larva swims. (D.)—An oyster larva almost ready to settle. It is now about $1/80$ of an inch long. (Drawings by A. B. Needler.)

of the oysters are very variable it is useless to attempt here to give the growth more definitely. The warmer the water the more rapid the growth tends to be, and it may be influenced by the amount of food in the water (the more food the more rapid), by the amount of silt from which the oyster has to sort its food (the more silt the slower), by the amount of salt in the water (too much or too little may be harmful) and other factors.

AGE AT MATURITY: In Bideford river (an inlet tributary to Malpeque bay) it was found that when in their second summer (one year old) as many as thirty per cent may produce sperms but hardly any produce eggs. When two years old almost all are mature, about three out of four being males and the rest females. As they grow older the proportion of females increases until among old oysters three-quarters or more may produce eggs.

SHAPE: The shape of an oyster is influenced by the conditions under which it grows. If growing on soft bottom where it sinks slowly, or if growing in a place where silt is settling, the oyster, being unable to move, must grow long to keep the lips of its shell above the mud. On soft bottom an oyster tends to be long and narrow, and its shape is roundest on hard, clean bottom. Under conditions which favour rapid growth it appears that the oyster grows flatter and has the edges of its shell less curved, the most "cupped" oysters being found where the growth is slow. When the water is too fresh the shells may be very thin. Crowding produces distorted shapes and clusters of oysters grown to one another. Oysters of the most valuable shape—i.e., most nearly round with strong, cupped shells and plenty of space filled with meat between the two shells—are produced where they grow singly on hard, clean bottoms where the water is relatively cool and salt.

B—THE NEED FOR OYSTER FARMING

IN CANADA WE ARE AT THE NORTHERN LIMIT OF THE OYSTERS' RANGE: Oysters of our species (*Ostrea virginica*) are found from Northern New Brunswick to Mexico. The greatest production is south of New York. Coming farther north the water gets colder until near Boston the oysters disappear. There are practically none north of Boston except those in the sheltered waters in the southern part of the gulf of St. Lawrence and in the salt Bras d'Or "lakes" in Cape Breton.

We have seen that oysters do not spawn in water colder than 68 degrees and do not feed in water colder than 41 degrees (Fahrenheit). In the southern part of their range the water is warm enough for feeding for all or almost all the year, and warm enough for spawning for several months every year. As we come north the conditions get colder and colder until in Canadian oyster areas only half the year is warm enough for feeding and only a few weeks for spawning—and that only in our most sheltered waters. As a result, the growth of our oysters is slow and the reproduction slow and uncertain. Our oysters take very much longer than the southern oysters to reach marketable size or to mature. When they have matured, spawning is uncertain and in some years many do not spawn at all, or spawn so late that the spat are too small to survive the winter.

THE OYSTER INDUSTRY OF THE NORTH: In the northern Atlantic oyster areas the production is slow and uncertain. As a compensation we have the higher quality of oysters grown in the colder waters either of the northern United States or of Canada. This high quality has led to a demand which the slow growth and uncertain reproduction has been unable to supply. Consequently, everywhere in the north the quantities of oysters have been reduced. In spite of restrictions on the fishing season, on the size of oyster to be taken and on the gear to be used, the oysters were everywhere seriously reduced in numbers and in some places were practically swept clean. In the face of continued public

fishing, and unassisted by cultivation of any kind, the natural production has nowhere in northern waters been able to maintain the supply at any but a very low level.

In the northern areas in the United States the depletion was hastened by the proximity of centres of population. Oyster farming was therefore necessary at an early date and was well established before 1900. By its development the northern oyster-growing states have been able to maintain at a high level an industry otherwise doomed to practical extinction.

THE COURSE OF THE FISHERY IN THE TYPICAL CANADIAN OYSTER BAY: In Canadian waters it is only in the sheltered bays that the water becomes warm enough in summer for the oysters to spawn, and within these bays there are great differences in the conditions. These influence both the quality and the rate of production of the oysters and, therefore, the course and the results of the fishery.

The production is influenced in two ways. In the first place the waters near the heads of the bay become warm enough for spawning in a larger proportion of the years, for a longer time each year, and earlier in the year. The oysters there are able to spawn in more of the years and more successfully each year. Towards the mouth of the bay spawning becomes less certain and less successful and in many places there is little or no spawning in many or even in most years. In the second place, the oysters grow more quickly in the warmer water near the head and more slowly towards the open. In the latter places they take longer to reach marketable size or maturity.

The quality is highest near the open and gets lower as we go up the bay. The saltier water near the open produces a better flavour. Where the growth is slower and the water more salt the shells are thicker and more cupped. The crowding and muddier bottoms farther up the bay produce long and distorted shapes. Thus, near the open we have high quality and slow rate of production, and towards the head high rate of production and low quality.

When a bay is first fished there may be large quantities of high quality oysters near the mouth. In the absence of fishing a considerable stock may be built up, in the course of decades or centuries, even where the rate of reproduction is low. The high quality oysters are the first to be fished, being more valuable, and because of this and their slow reproduction they are the first to be fished out. As long as new beds are being discovered and fished the yield of the bay is kept up but in the course of time all the areas producing fine oysters are fished over. The fishery then turns to poorer oysters farther up the inlet with the result that the quantity and quality of the oysters obtained both decline. The decline of the quantity is clearly shown in the accompanying graph of the landings of oysters from the Malpeque Bay area. The average quality in this area also declined because, although some of the best quality still remained, more and more of the oysters landed came from farther up the "rivers."



FIGURE 2. The landings of oysters in the Malpeque Bay area as shown by the statistics of the fishery. It is clearly shown that the yield had been reduced by public fishing, to a small fraction of its former size, before the disease of 1914-1916 completed the destruction of the fishery.

In practically every oyster producing bay in our waters the same story has been enacted or is in progress. In some bays only very poor oysters are left in the uppermost reaches—so poor that the yield is almost gone but enough oysters are taken to prevent recovery. In other bays the process has not gone so far and the yield has merely been greatly reduced.

OYSTER FARMING: It is evident, then, that natural production of oysters in northern waters is not sufficient and that some help must be given; and it is here that the oyster farmer finds his place in the scheme. While in nature it is difficult for the young spat to find places to settle that are free from slime, the farmer can supply clean material at the right time. Again, it has been pointed out that better quality oysters are produced in waters where growth is slow and spawning uncertain. Here the farmer can raise the standard and make use of a greater area by collecting his spat in the warmer, fresher water and later moving it to the beds where the oysters get a desirable shape and flavour. Thus cultivation is desirable for two important reasons. It can increase the production and it can improve the quality of the oysters. It is in the interest of the whole community that this should be done.

C—PREPARATION OF THE GROUND

The first step in oyster farming is to prepare the ground for planting oysters or for collecting spat. In preparing the ground two aims are important:—(1) to obtain as hard and clean a surface as possible, and (2) to remove enemies and competitors of the oysters.

1. IMPROVING THE SURFACE. The Bottom Must Be Clean and Hard. As we have already seen, oysters cannot move and need a bottom firm enough to keep them from sinking. On soft bottoms oysters keep the “lips” of their shells above the surface by growing long and narrow. The softer the bottom the longer and narrower they grow, until we come to bottoms so soft that the oysters sink and die. The oysters of best shape are grown on clean, hard bottom.

An especially hard and clean surface is needed for planting oysters. Some will reach the bottom with the lips of their shells down, and these will smother in a small amount of mud. This is particularly true of spat, which are so small that very little mud will cover them, and most of the spat which reach bottom on the under side of a shell die. Part of the oysters are killed whenever transplanting is done, the loss varying from hardly any to almost 100%, depending chiefly on the firmness of the ground. *For planting oysters it is very important to have the ground as clean and hard as possible.* One must not be misled by finding oysters growing on fairly soft bottoms. They settled on an exposed piece of shell or stick and started their growth upwards as the piece sank, and so they survived, although usually of very poor shape.

A hard, clean surface is also important for the collection of spat. (See the section on “Collection of Spat”). The young oysters will settle best on exposed, clean surfaces, and on soft bottoms much of the surface of the shells (or other material used for the oysters to settle on) is lost by being buried. It is pointed out, however, that when shells (or other materials on which oysters will settle) are used to harden the surface, it is worth while to spread them at the right time for collecting spat. Although the shells will catch only a relatively small number of spat if spread on soft bottoms, a few spat may be obtained and survive if the shells are spread at the right time.

Different kinds of ground require different treatment. The grounds which can be made suitable for oyster culture without excessive expense are (1) old oyster beds or accumulations of shells from a few inches to many feet in thickness, and (2) hard bottoms without shells, including gravel, stationary sand, hard mud, mixed mud and sand, or even flat rock ledge. Soft mud and shifting sand are both quite unsuitable.

Old beds, if clean, present a good surface without improvement, but it will often be found that there is a covering of silt over the bed which may be several inches in thickness. For example, most of the beds in the upper parts of the

inlets or "rivers" in the Malpeque Bay area have a covering of silt. If the layer is thin it can be removed by lifting the surface material with tongs fitted for washing shells, washing out the mud and either dropping the shells back or landing them. By landing the shells and leaving them ashore for some time, until the silt and slime is cleaned off, they can be used for catching spat. If dropped back on the bed immediately they are not nearly as good for that purpose and, even if spat could be obtained in fairly good numbers on the bed by using clean, weathered shells, very few will be obtained by shells washed and dropped back immediately. It is usually worth the extra labour of landing the shells, unless the farmer has another large and less expensive source of material for catching spat. As some beds are

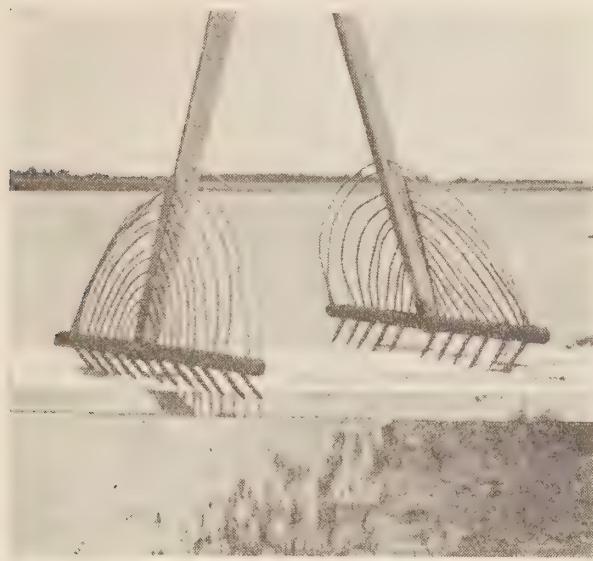


FIGURE 3. Oyster tongs fitted for washing shells. The wires make it possible to hold shells in the tongs and shake them vigorously in the water. A similar basket-work may be made of wire netting on iron supports, which is as effective and less expensive.

only a few inches thick in places care should be taken not to remove too many shells from any thin parts.

Dredges, although involving more expense at the start, may be well worth while for lifting shells from the surface of a bed. They work best where there are large areas of unbroken ground, and are less worth while where the hard ground is in small pieces or has an irregular surface. Dredges which can be used from ordinary motor boats can be obtained for fifteen or twenty dollars. A large number of devices have been suggested and used for cleaning the surface of beds, such as harrows raising the mud to be carried away by the tide, etc. The conditions are so varied and so few systematic trials have been carried out that the oyster farmer must be guided largely by common sense in choosing his method.

When starting he will do well to examine his ground carefully and prepare the best of it first, as the improvement of poor ground is expensive. It is better to put a small amount into really good condition than twice as much into only fair condition, because there is always danger of wasting time, work, and money obtaining spat or young oysters and planting them on ground poor enough to destroy a large proportion.

Firm grounds other than shell beds do not offer the chance of improving the surface and obtaining a supply of shells at the same time. Some *hard sand, mud, or muddy sand bottoms* are suitable for planting with little or no improve-

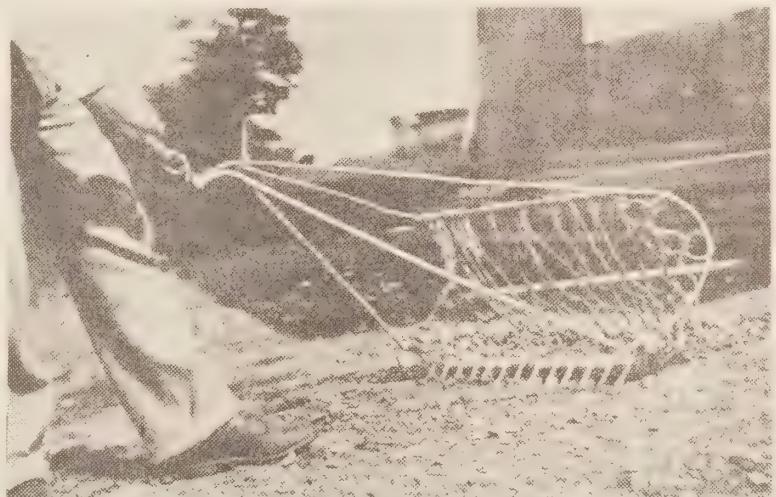


FIGURE 4. A small dredge which can be operated from a motor boat and lifted by hand. The framework and teeth are of galvanized iron, the back is of soft-laid cotton rope and the bottom of galvanized iron rings. (Photograph by A. B. Needler.)

ment. *Softer grounds* may be improved by the addition of sand or gravel, which will harden some bottoms sufficiently to prevent shells from sinking. Sand which has a tendency to shift is dangerous but the shifting can sometimes be prevented by shells.

Much ground which is not shell bed is used successfully for growing oysters. Indeed, old shell beds form only a small proportion of the ground which is used where oyster farming is well developed. In our oyster areas the hard beds usually are the best available grounds but other firm grounds should not be passed by.

2. REMOVAL OF ENEMIES AND COMPETITORS. The enemies (animals which kill and eat oysters) and the competitors (animals which live with the oysters and eat the same food or try to occupy the same places) are of many kinds. In our waters the only enemy known to be serious is the starfish. The most serious competitor is the mussel, with slipper limpets or "double-deckers" (*Crepidula*) and others less important. Practically all shellfish which are found with the oysters rank as competitors.

Starfish are a serious menace in many places. Usually they are most abundant towards the mouths of the bays where the water is saltiest, but in some localities quite a few are found a long way up the inlets. In certain areas in our waters starfish are so scarce as not to be a serious enemies.

Starfish destroy oysters by opening them by steady pulling. They then eat the meats and are able to turn their stomachs out of their mouths to envelop their food.

Starfish are most destructive to spat and small oysters but large ones will attack large oysters. One starfish may destroy many spat in a day and if spat are put where they are numerous a large proportion will be killed before the first winter. If they are numerous the removal of starfish is an important step in the preparation of ground for planting or collecting spat.

Whenever starfish are seen in cleaning or fishing operations they should be killed. This is most easily done by putting them ashore and leaving them there. They will survive an astounding degree of mutilation and it is little or no use to tear them up and throw them back. At times they appear in shallow water in large numbers and at such times large quantities can be destroyed by picking them up at low tide.

If starfish are numerous it may be worth while to catch them by "*mopping*." This method has long been used in the United States and although it involves some expense it is still in regular use. The mops are made by knotting two- or three-foot lengths of cotton (as fine and kinky as can be found) to a wire about two feet long. The knot is a simple one in the middle of the length of waste and as many lengths of waste are put on each wire as it will hold, being kept on by rings or stops of some kind at the ends of the wire. A number of these mops are then fastened by short pieces of chain at intervals along an iron bar five to ten feet long which is part of a triangular frame. There are circular twists of the bar at the end, like wheels, to keep the bar off the bottom to prevent damage to the oysters. The mops are towed *slowly* across the bottom, care being taken to avoid getting the rope tangled in the propellor. After the mops have been towed for a while they are lifted into the boat and the starfish removed. Dipping the mops into hot water is an efficient method of killing the starfish and removing them. It can sometimes be arranged to heat a trough of water with the exhaust of the engine.

Efficiency is increased by mopping at intervals of two or three days. The starfish are caught by the mops by the threads getting tangled in the roughnesses of their surfaces. Those starfish which are in sheltered positions do not get tangled or hold fast enough to break the threads. By repeating the mopping after a short time, they are given a chance to move and become exposed. A number of moppings at intervals are more effective than the same amount all at one time.

Mopping takes time and money, and whether it is worth while depends on the abundance of the starfish. Any method of removing the starfish is most effective if practised by as many farmers as possible, since starfish, although they do not move quickly, can in time spread from one area to another.

Mussels and other competitors should be removed. Mussels at times grow in such quantities as to smother the oysters on which they settle, being helped by the accumulation of silt among them. They also eat the oyster's food.

The mussels can be removed by tonging, dredging, or raking. If taken ashore and left for some time their shells can be used for the collection of spat. It is pointed out that in the case of old beds the removal of mussels is done at the same time as the surface is cleaned. Thus, with one operation, the mussels and other competitors are removed, the silt cleaned off and a supply of shells for collecting spat obtained.

D—THE COLLECTION OF SPAT

The collection of spat is the chief means of obtaining stock for growing. It may at times be possible to get year-old or older oysters for planting, but the industry as a whole must rely on the collection of spat—that is, increasing the number of larvæ which settle and survive by providing clean material for them to settle on at the right time and place.

WHEN TO PUT OUT CULTCH: The larvæ of the oyster require clean, firm surfaces, free from silt or slime, on which to settle. As most objects in the places where oysters grow soon become coated with slime (minute plants) or silt, the number of larvæ which settle can be greatly increased by providing clean material ("cultch") at the proper time and place. To get the best results it is necessary to provide the cultch just before the larvæ are ready to settle, because the silt or slime soon appears. This makes necessary the prediction of the time when the larvæ will attach themselves and become "spat."

It is important to realize the great advantage of clean cultch placed in the water at the right time. Clean shells put out just before the settling or "setting" of the larvæ may collect hundreds of spat when it is difficult to find even one or two on the "natural" shells lying about the shore which have been there all year. This is the rule rather than the exception and is due to the slime or silt on the "natural" shells.

In order to know when to put the cultch in the water we must know when to expect large numbers of larvæ to settle. For this we must refer to our knowledge of the oysters' method of reproducing. Our oysters will not spawn until after the water has warmed to 68 degrees on the ordinary thermometer scale in common use—the Fahrenheit scale (usually written 68° F. to distinguish this scale from the international scientific scale or "Centigrade" scale on which the same temperature is 20 degrees or "20° C."). As the free-swimming stage of the oyster's life lasts for two to three weeks in our waters, it is never desirable to have the cultch in the water before two weeks after the temperature of the water has reached 68° F.

With a little care and practice anyone can determine the temperature, using a reliable thermometer. Care must be taken to read the temperature *when the bulb of the thermometer is in the water*, as the thermometer will show a different temperature almost immediately after being taken out of the water. This reading can be done conveniently by drawing a bucket (or other *large* quantity) of water and taking the temperature *immediately*. Thermometers are sometimes wrongly made and unreliable and it is well to check them by comparison with reliable ones.

We see that cultch should not be put out until two weeks after the temperature of the water in which it is to be placed reaches 68° F. But this is not all. Oysters will not spawn until the temperature reaches 68 degrees, but the bulk of the spawning may not take place until some time later. As soon as the water approaches 68 degrees oysters should be examined to see when the bulk of the spawning takes place. By opening the oysters the spawn (eggs or sperms) can be seen as a milky layer over the surface of the body. Because all oysters do not necessarily spawn at the same time and do not have the same amounts of spawn a number of oysters should be examined. An oyster does not release all its spawn at the same time and it is difficult to estimate how much of the spawn has been shed. When most of the spawn has been shed there is an appearance of branching milky veining on the surface of the oyster's body, instead of a continuous milky layer. As soon as it seems that any large proportion of the spawn has been shed, the cultch should be put out almost immediately. This advice is given because it is better to be early than late and it is easy to miss a considerable amount of spawning.

To SUMMARIZE: Spawning will not start until the water has warmed to 68° F., and the bulk of the spawning may not be for some time later. When this temperature is reached, examining the oysters will show when a large amount of spawning has occurred. Larvæ will not settle until two to three weeks after spawning but it is well to put out the cultch as soon as any large amount of spawning has been seen by examining the oysters.

WHERE TO PUT OUT CULTCH: In choosing a place to collect spat the following requirements must be met.

(1) There must be oysters near by in sufficient numbers to produce the larvæ. Naturally the more oysters the more larvæ, other conditions being similar. There is evidence that the great bulk of the larvæ usually settle fairly close to where they are spawned.

(2) The place must be well enough sheltered from the open to make its water temperatures high. The shallow water and the parts of the bays and "rivers" farthest from the open warm up most in summer. The water on the oyster beds nearest the open may get warm enough for spawning only in exceptionally warm years. It is at the heads of the inlets that the water is most certain to become warm enough. (Where there is a great inflow of fresh water, such as occurs in some rivers on the mainland, the water is too fresh for oysters for some distance below the head of tide. There, of course, only areas farther down must be used. It is pointed out, however, that almost all the bays and "rivers" of Prince Edward Island, and some of those on the mainland, have fairly salt water to the head of tide, the brooks being small because they drain small areas.)

(3) The depths at which spat can be collected in Bideford river, Malpeque bay, range from half-tide level to the bottom of the river, with the greatest abundance apparently just below the level of an ordinary low tide, and with the abundance decreasing gradually at greater depths. Fragmentary observations elsewhere in our waters have suggested a similar distribution.

(4) There must be bottom conditions suitable for the kind of cultch used—such as hard, clean bottoms where loose shells are used etc. (See below.)

Many different methods of collecting spat exist in which various kinds of cultch are used and are put out in various ways. The prediction of the time when the cultch should be put out applies to all the methods and so do the above remarks on where to put it. In all cases the cultch must be put out at the right time and place. In addition, the following principles are important:—

- (i) The cultch must have surfaces on which oyster larvæ will settle. These include a very great variety, such as shells, stones, leather, bottoms of boats and scows, cement-covered cardboard, brush of certain kinds, iron, etc., etc.
- (ii) The material must be cheap.
- (iii) The material must be easy to handle and must be handled as conveniently as possible.
- (iv) Protection of spat from enemies may be important.

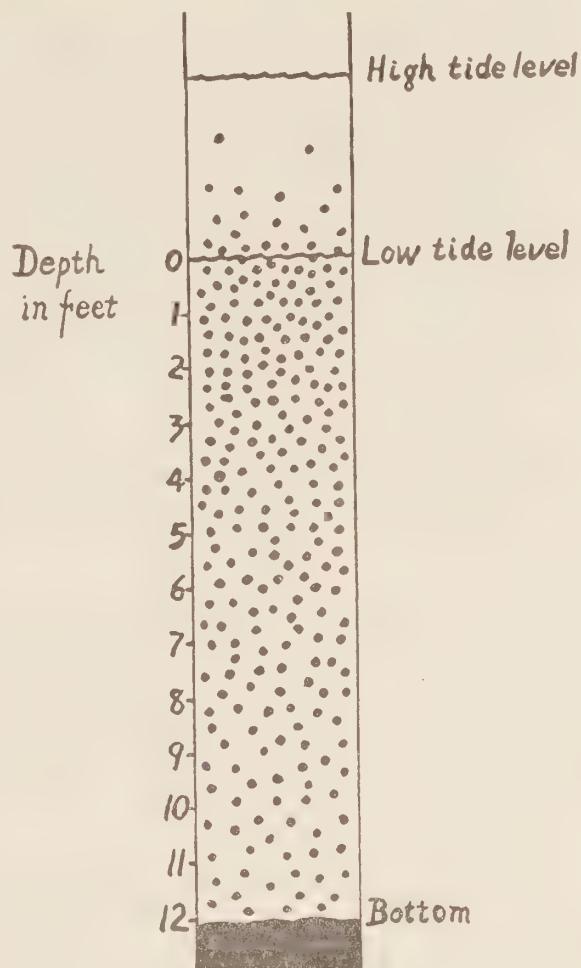


FIGURE 5. The relative abundance of spat settling at different levels in the Malpeque Bay area.

Every farmer has a slightly different problem and must suit his method of collecting spat to his own needs and opportunities. There is plenty of room for change and improvement in the methods of spat-collecting and every oyster farmer should try his hand at finding the best method for his own situation. The methods outlined below have been tried in Bideford river, Malpeque bay. They are suggested as methods which have met with some success in our waters but they are not necessarily the best possible.

USE OF LOOSE SHELLS AS CULTCH: In some cases shells spread loose on hard bottoms are very suitable as cultch. This is especially true when it is intended to leave the young oysters to grow on a bed where there is good probability of obtaining a "set" of spat. When spat is collected to be planted elsewhere, other methods such as using shells in wire baskets are more convenient. But even in these cases loose shells may at times be used to advantage as they form a good kind of cultch to use on hard beds.

The shells are simply put overboard and spread in a layer on *hard, clean* bottom. If the spat is to be taken up and moved again, a layer some inches thick may be spread and spat be obtained throughout. This is, of course, a waste of shells if the spat is to be left in the same place, because the lower spat will only be crowded out and smothered.

The *expense* of spreading is small and depends on the source of supply of the shells and on the weather. The cost of obtaining shells will vary so much that it is useless to estimate it here.

The *bottom* should be clean and hard. Sandy shores are poor for spreading shells loose because the waves soon bury many of the shells.

The *time* of spreading is as important as it is with all kinds of cultch. (See above). The shells will be covered with slime and silt soon after spreading.

The *kind of shell* is not of great importance. Little difference has been observed between the numbers of spat settled on oyster, clam, mussel, quahaug or slipper-limpet shells. But the shells must be clean and the slime should have been killed by weathering.

The *number of spat* collected on shells spread loose compares well with the number obtained in the same places on shells in wire bags, as long as the bottom is hard and clean. In most places many of the shells become wholly or partly buried. An average of from four to fifteen spat per shell has been found on the uppermost shells put out in this way on certain grounds in the upper part of Bideford river.

USE OF SHELLS IN WIRE BAGS: This method, developed in the New England oyster areas, has been tried in Bideford river in several different seasons.

The *wire* used for the bags was No. 17 wire in inch and a half hexagonal meshes galvanized before and after weaving. Ordinary chicken wire rusted in a single season so as to be useless for the next while the heavy wire above has lasted two seasons without evident damage.

The *method of making* the bags was as follows: Netting three feet wide was used and three foot lengths were cut. Each length was rolled to form a cylinder and the edges laced together with No. 18 lacing wire. One of the ends was sewn up at once and the other sewn after the bag was filled with shells.

The *shape* of the bag made in this way was cylindrical. It was about three feet long and one foot in diameter.

The *capacity* of each bag was nearly a bushel.

The *cost* of the bags consists of the cost of the wire and of the labour in making them. The netting in each bag cost about 18c. and a man can make thirty or forty bags in a day.

The *shells* used should be large and free from mud. They should have had the slime and mud removed by exposure to the weather. It is well to remove dirt by screening through a piece of the netting used for making the bags. Oyster shells are preferable to mussel shells, which fit too closely together and prevent the penetration of the spat into the interior of the bag.

The *time* when the bags are put in the water is important and has been discussed above.

The *place* where the bags are put out is along the shore just below the level of an ordinary low tide so that they barely show above water at low tide. This place is convenient for examination and for picking up the bags to plant the spat.

The bags may be *piled* two on two in piles of six or more, or stooked like sheaves of grain. If the bottom is soft, slabs or poles may be put under them to keep them from sinking. A sort of hand barrow of two poles may be made with the bags laid across in numbers convenient to lift, and the whole put in water.

The *number* of spat obtained in each of the years 1929, 1930 and 1931 in the upper part of Bideford river was from 2,000 to 4,000 per bag.

The *distribution of the spat in the bags* is of importance. The outside of the bags obtained most spat, the lower surface being the best. In a typical bag only 13 per cent of the shells had no spat, 65 per cent had 1 to 10 spat, 16 per cent had 11 to 20 spat, and 6 per cent had more than 20. Thus, few of the shells had no spat and few were badly crowded.

Among the *advantages* of this method are the convenience of handling and the fact that bottoms may be used along the shore where spat are abundant and which are unsuitable for loose shells. The bags can be prepared and filled ahead of time and are quickly put in the water. The disadvantages include the necessity of lifting and emptying the bags and planting the spat before winter. This would not be necessary were the bags put out of reach of the ice, but they must be emptied when the spat are still young as the shells soon grow together, the spat towards the centre of the bag die and those on the surface are crowded.

OTHER METHODS: Other methods are now being tried in our waters but have not yet reached the stage of satisfactory use.

The use of *brush* is being tried. If successful its advantages would include: (1) There is an almost unlimited supply; (2) It is cheap to obtain and put out; (3) It can be put out over bottoms too soft for shells and where spat are abundant; (4) Shipworms eat out the brush so that it is easy to break it up and produce "single" oysters. The brush has been put out in faggots wired together with lacing wire and held down by a stake through each bundle. Thus far it seems that brush newly placed in the water is not effective in catching spat while brush which has been seasoned in the water may catch good numbers.

The use of *cardboard collectors coated with cement* which is being developed in the United States is being tried here. The collectors resemble egg-crate partitions in shape and cost about two cents apiece. They are dipped in a mixture of lime, cement and sand, and placed in a number of different positions. In the United States some are placed directly on the beds, or they may be put near the shore. They do not, however, withstand wave action well and although it has been shown that they will collect good numbers of spat they are troublesome to handle.

E—PLANTING THE SPAT

We have already pointed out that *clean, hard* bottoms are needed for planting spat, which are so small that they are readily covered by a small amount of mud. On dirty grounds only those which are kept out of the mud, by the shell or other cultch to which they are attached, will survive.

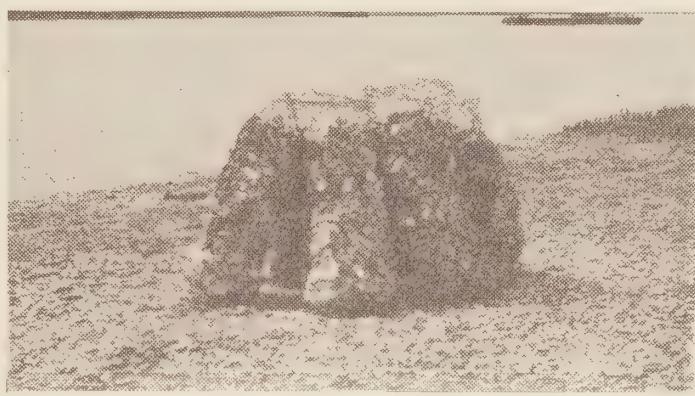


FIGURE 6. Wire bags filled with oyster shells, showing one of the ways of putting them out—stooking. When actually used to collect spat they are, of course, placed farther out where they barely show above water at low tide.

Other factors also play a part. *Any sudden change in conditions* is likely to be harmful to oysters. Although they will often recover and survive to grow and thrive, transplanting to water of different temperature or saltiness is likely to cause a check in growth and, if the change is too extreme, may kill them. The risk in transplanting is increased when the conditions in the two places are very different.

Oysters will survive exposure to the air better in cool weather than in warm (as long as temperatures near freezing are avoided). In general the larger the seed oysters the better they withstand exposure. Very small spat are easily harmed in this way.

During warm weather when the oysters are growing rapidly there is often a considerable fringe of very soft thin shell (the "shoot") which is easily broken. In the periods of slower growth this fringe is hardened. Although breaking the fringe does not necessarily kill the oysters it may do so and it is at least a setback.

All these considerations must be taken into account in deciding when to move spat from the grounds where they are collected to grounds where they are to be grown, or in deciding when to move oysters of any kind. In general it is *best to move oysters in the cool weather of the autumn or spring* for the following reasons:—

- (1) The temperatures are more uniform in the inlet than than in the summer. In warm weather the water near the heads of the bays and rivers is usually much warmer than nearer the open.
- (2) The weather is cool and the oysters will stand exposure to the air better.
- (3) There is less soft thin shell that can be broken.

It seems that very small spat are particularly susceptible to harm in transplanting. In an experiment in 1930 spat collected on bags of shells near the head of Bideford river, Malpeque bay, were planted on a bed some distance down the inlet at three different times—near the beginning of August just after they had settled, at the end of August, and at the end of September. At the end of November, just before the final freeze-up, almost all of the first lot, about 70 per cent of the second lot, and only about 35 per cent of the third lot were dead. In spite of mopping some starfish were still present on the bed and doubtless caused some of the damage. But the larger spat were apparently better able to withstand the transfer.

Spat which are collected in the shore zone within reach of the ice must be planted before winter. It is recommended that this be as late as possible without exposing the spat to freezing. At this time the general conditions for planting as outlined above are best, and the spat have had time to grow so as better to withstand the transfer. It is also pointed out that the spat can be protected from starfish better in the shallow water where the cultch can be examined at low tide and the starfish picked off. The spat are thus protected at a time when they are most likely to be destroyed.

Spat which settle on cultch planted out of reach of the ice need not be moved before winter. Such spat may be left in place until fished to be marketed or may be transferred at some stage to other grounds. The considerations which determine whether or not the spat should be moved and when to move them may be briefly reviewed:

- (1) In our waters spat can usually be collected best near the heads of the inlets where the water warms most in summer, and some grounds nearer the open are suitable for growing high quality oysters but not for catching spat. These lower areas must be stocked by bringing "seed oysters" of some age from farther up the inlet.

(2) In the warmer and slightly fresher water towards the heads of the inlets oysters grow more rapidly than farther down but are not of such good quality. Oysters may be left on the good growing grounds until one, two or three years after the season when they settle as spat and may then be transferred to grounds farther down. The longer they are left the more they will have the advantage of rapid growth but the less likely they are to have the best shape developed on the lower grounds.

(3) It is often believed that the oysters will withstand the transfer to somewhat salter water better when they are older. There seems to be some probability that this is the case but it needs further testing. It is true that larger oysters stand exposure to air better than spat, that they survive better if planted on a bed with a thin covering of silt, and that they are less quickly destroyed by starfish which are usually more abundant on the grounds near the open.

(4) If spat are left on the bed where they settle they prevent the use of that ground for spat collecting again until they are moved. If a ground is particularly good for catching spat it might be most profitably worked by collecting spat on it and transferring the spat at an early age, either to some other part of the same farmer's ground or by sale to other farmers who have not the same opportunity or success in catching spat. It is necessary for each oyster grower to decide in what way he can best use any particular piece of ground—for collecting spat or for "growing" ground.

August, 1932.

